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ABSTRACT

This study examined how middle school teachers co-constructed norms and practices related to classroom use of laptop computers, focusing on a school that gave laptop computers to teachers, provided appropriate professional development, and offered students access to laptops. Eleven teachers were eligible to be study cases. During the first year, they were interviewed and observed. Researchers also interviewed administrators, conducted student focus groups, and observed faculty and board meetings. Teacher interviews examined beliefs about teaching and learning and teachers' instructional planning. In the second year, over 100 hours of participant observation occurred. Three teacher cases were shadowed throughout the school day, and teacher-researcher discussions were recorded. The resulting case studies described developmental changes associated with teachers' learning to use laptops in class. Conversations flowed through the school's network of settings that came to define the normative playing field for teachers' curricular decisions. Teachers' participation in these settings depended upon access to the activity and access to the social language used in the setting. Consistent teacher descriptions of peer choices to use or not use laptops indicated that access to the social language led to their understanding of the various roles laptops played in the school. (Contains 51 references.) (SM)

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Teachers Learning to Use Technology Within the Context of a Laptop Learning Initiative: The Interplay of Personal Histories, Social Dynamics and Institutional Culture

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Teachers Learning to Use Technology Within the Context of a Laptop Learning Initiative:

The Interplay of Personal Histories, Social Dynamics and Institutional Culture

One of the fastest growing and most under-examined "experiments" in American schooling is the programmatic infusion of laptop computers into the lives of students and teachers. Increasing numbers of school communities are making the decision to commit extraordinary resources to such initiatives, which, in their various incarnations, place sophisticated, multipurpose technological tools in the hands of every student and on the desk of the teacher. The unique conditions of personal, pervasive and mobile computing open up new possibilities for when and where children learn, and, have potentially profound implications for how children learn.

Teachers in these programs are faced with a set of daunting tasks— develop a working technological literacy, to manage classrooms in which all students have mobile computing and communication, understand how computers can facilitate the existing curriculum, and, most challenging of all, to envision how these new tools can transform teaching and learning. Unfortunately, most of the literature on laptop learning environments is superficial, anecdotal, and grossly under-theorized. The research on teacher learning in technology-rich environments in general is much more rigorous, yet has documented that teachers can and do change their instructional practices when using technology but has failed to reveal how or why they transform their practice over time. Part of the reason for the lack of explanatory in this research base is that so many studies have been devoted to tracing changes in individual teachers' knowledge, beliefs, and instructional practices while ignoring the fact that teachers' lives are situated in particular social, instructional and cultural contexts which shape the meaning of their work. Past approaches to studying teacher learning have noted the importance of contextual factors such as the characteristics of staff development experiences, access to technology, or opportunity to interact with colleagues however these factors are often treated as variables whose effects contribute in various magnitudes to the behavior of individuals.

Recent scholarship on teacher learning has shifted the focus from the individual teacher as the unit of analysis to the groups of communities in which teachers participate (Stein & Brown, 1997). Cognition, in this view, is social in nature and distributed across individuals and the tools (e.g. computers) they use to mediate their activity (Putnam & Borko, 2000). Attention is shifted from the individual to the various groups and settings in which learning occurs; instead of learning being located in the cognitive structures and mental representations of individual teachers, it becomes situated in the "fields of interaction" among individuals (Hanks, 1991; [cited in Stein & Brown, 1989, p. 159]). Learning is viewed not as the accretion of knowledge, but as the increasing ability to participate in meaningful and productive activities.

This perspective of teacher learning as socially situated and distributed in nature is linked with another dimension of teacher learning that is receiving increased attention— that learning takes place in specific contexts whose social structures have been developed through historically and culturally grounded actions. School cultures are infused with notions of ideal futures for students and teachers that are promoted through the ways in which cultural activity is structured. Students and teachers aspire to culturally-defined futures that motivate their activity and the ways in which they mediate one another's progress toward those goals (Grossman, Smagorinsky, & Valencia 1999).

In attempting to reveal the nature of learning in technology-rich environments, these sociocentric perspectives (Soltis, 1981) draw upon both sociocultural and situative (Greeno, 1997) theory to take into account teachers' experiences that have either been ignored or remain invisible when examined through the lens of individual cognition— experiences such as co-constructing knowledge about technology and the curriculum, not only with peers, but also with students, making sense of the use of technology by coordinating one's personal history of teaching with the expectations of the institutional culture, and participating in increasingly productive ways in formal and informal school settings that are focused in the

use of technology. Because these theoretical perspectives recognize 1) the co-construction of knowledge among teachers and students, 2) the cultural contexts that mediate expectations for teaching and learning, , and, 3) the more immediate social settings in which teachers participate, they may be able to move us beyond what teachers learn and help us understand how and why teachers come to use technology in new ways over time. Laptop computer programs provide a unique environment in which to illuminate these kinds of phenomena.

Background

The Emergence of the Laptop Phenomena

In 1996, approximately 50 schools in the United States piloted laptop computing programs. Five years later, more than 100,000 students and teachers at more than 800 public and private schools are using notebook computers in the classroom.

Laptop computers have become symbols of mobility, freedom, and personalized learning, but perhaps most importantly, they have been pitched on a higher plane as instruments of equal access to education. In efforts to support and proliferate these programs, various consortia have united schools, districts, consultants, and the technology industry.[1]

Laptop programs in schools can differ along several dimensions. In some programs, every child in the school has his own computer. In other versions of laptop programs, only students in selected classrooms within a school will have laptop computers; and, in still more modest programs, limited numbers of laptops are kept on carts and used in classrooms as needed. "Who gets" the technology is often tied to "who pays" for it. Some programs are funded almost entirely by grants, and students' families are not required to purchase the requisite hardware and software. Other programs require students' families to make significant financial commitments by purchasing the computers themselves— a sum that commonly exceeds $2000 per child. In the most comprehensive laptop programs, all students within a school or grade level own their own computers, bring them to every class each day, and take them home each evening.

One of the basic assumptions of this study is that, in contrast to the more conventional presence of desktop technology in schools, laptop programs create novel circumstances in classrooms and introduce special features to the institutional landscape that distinguish laptop schools environments from other environments in which there is pervasive desktop technology. This assumption has two threads of logic: the first one deals with the affordances of the laptop technology itself and the types of learning activities that it supports, and the second deals with broader programmatic issues accompanying the introduction of laptops that involve pedagogical, curricular, administrative, fiscal, and even cultural concerns of the school community.

With regard to the affordances of the technology itself, laptops have all of the computational power and connectivity of the most advanced desktop computers. Laptops are portable, which, in a school setting, means that they can be carried from class to class, used on top of a desk, carried around the room, or placed out of sight; they can be stolen, dropped, shared, customized, or confiscated. At a moment's notice, a student can pull the computer from his backpack, lift the cover and instantly make this tool part of the classroom environment. Just as quickly, he can pack it up and stow it under the desk. Because students often own their laptops, they become personal devices for storing information and a tool for organizing their work schedules. Portability combined with ownership mean that students will have the same set of tools available to them throughout the school day. It also means that students can take them home with them the digital products of their daily work as well as the tools that created them.

Laptops are almost always more recent technologies than what one would find in a computer lab in a school, and, in most respects, they are orders of magnitude beyond the technology used in previous studies of technology-rich schools. The laptop can be considered a tool but it metaphorically is more akin to a Swiss army knife— a "base technology" that supports the use of a myriad of symbol-processing tools that help students gather, store, organize, analyze, re-present, and communicate information and ideas. Portable

computing has emerged roughly in coincidence with the rise of the World Wide Web and the widespread use of e-mail. These telecommunications functions mean that every child can access government census database, download photographs of the Civil War, track weather around the world in real time and follow the passage of a bill through congress. Students can take virtual tours of the Lourve, become part of a research community with students from other schools, or place personal projects on their own web pages for a world wide audience. In sum, the potential uses for portable computing and telecommunications in classrooms is staggering; the ways in which teachers come to exploit this potential has yet to be documented.

Another way in which laptops create a novel context for teaching and learning deals not with the technology itself, but with the opportunities and tensions associated with "programs" that usher the use of laptops into a school. The introduction of laptops is often preceded by some kind of community dialogue among teachers, parents, and administrators around the role of technology in the lives of children. The various educational stakeholders in these conversations have special issues and concerns: teachers wonder how they will adapt to the presence of these new tools and what kind of support they will receive to learn to use them; principals contemplate the administration of such programs and they consider changes to the life of the school, such as the daily schedule, teaching assignments, or in-services; school board members may wrestle with how technology will help the school achieve its mission and how policy can facilitate the attainment of curricular goals; and, parents, many of whom maintain only a passing interest in school decisions, find themselves passionately involved in deliberations about laptop programs. In many cases, parents are compelled to weigh out the implications of their children's lives in schools being intimately connected to an instrument of high technology, and, the personal financial commitment necessary to have their child be included as part of a laptops program.

There has been very little written about how laptop programs evolve from idea to reality, who is included in key conversations, or how decisive arguments are framed; however, if parents are asked to lay out significant sums of money for the purchase of computers, it is reasonable to assume that teaching becomes more public than ever. Because the financial sacrifices of parents results in a one-to-one student-computer ratio in all classrooms the pressure for individual teachers to use technology increases.

Having laptop technology in every classroom raises certain possibilities for teaching and learning, but the mere presence of technology does not ensure that pedagogy will change. Taken optimistically, laptop programs have the potential to generate conversations among faculty about how to use technology to its greatest effect, or just what its "effects" are. Vis-à-vis these conversations, every teacher in the program is "connected" by the presence of technology in their classroom and opportunities arise for teachers of different subject matters to enter into conversation with one another over goals for learning and the role of technology in achieving those goals.

In laptop classrooms, teachers often find their roles reversed with the students', that is, they become the novices with regard to the use of technology and many of their children are the experts. Even if teachers are technologically proficient, many lack the understanding of how the various tools of technology can be incorporated into their existing classroom structure, and perhaps most importantly, few are able to envision how technology can facilitate new and more sophisticated learning activities. Not only is the teacher decentered as the hub of classroom activity, but the classroom itself can change shape. "Places and spaces" in the classroom are more fluid with laptops. Teachers must consider how to execute curriculum and manage classrooms in which learners can pick up their computers and sit with others who are working on similar problems, or can bring the computer to the teacher with a question, or be connected with learners outside the classroom. If permitted, students have new flexibility in approaching their work and organizing themselves to do this work. Many of these emerging classroom conditions are novel, many are problematic, and all take place within the shared domain of the student and the teacher.

The discussion above has not been as much about technology as it has been about context. The machines, their introduction into a school setting, their presence, their roles are not neutral. These programs

have to potential to both perturb the normal order of schooling and re-define the institutional environment. In short, laptop programs are enacted within and can become part of the social and cultural milieu of a school.

While the inertia behind the spread of laptop programs continues to grow, evidence of the effects of this kind of technology-saturated environment on student learning is conspicuously absent or confounded by a host of extraneous variables. Long-term investigations of teacher learning that take into account the social and cultural context of the teaching environment and are sensitive to the multitude of ways that teachers can learn, are almost non-existent. We know very little of how or why teachers in these programs learn to use technology to support their existing curriculum, explore new avenues for learning, or manage classrooms characterized by ubiquitous and mobile computing.

Teacher Learning in Technology-Rich School Settings

Researchers have only recently invested themselves in serious study of how teachers come to use technology in their classrooms and what kinds of influences shape their thinking (Kerr, 1996). Most of the existing research on the use of technology by teachers has focused on associations among variables such as the availability of new technology, frequency of use, and attitudes toward technology, and these studies have looked neither at how teachers learn nor the multiple contexts in which they learn.

Much of what we do know about teacher learning in technology-rich settings comes from the Apple Classrooms of Tomorrow (ACOT) project about which data has accumulating since 1985. The ACOT project equipped a single classroom in each of five schools with software, printers, laser disc players and, of course, computers— one for each student and teacher in the classroom, and one additional computer for each student and teacher for use at home. ACOT project leaders supported teachers' use of technology, but did not impose any particular instructional models or ideology on the teachers.

As ACOT researchers accumulated records, in the form of observations, teacher logs, and students' work, they conceptualized five stages of technology integrate by teachers. In the entry stage, teachers are not yet comfortable with computers and typically choose not to use them; they maintain traditional methods of teaching, and, when technology is made available to them, they are often frustrated with the management and discipline issues that arise. The adoption phase is characterized by teachers beginning to use the technology to support traditional teacher-centered methods. In the adaptation stage, teachers discover that they can use technology to accelerate coverage of the curriculum, which leaves more time for higher-order thinking. The appropriation stage occurs when teachers begin to use technology as a tool to develop new methods of instruction. Their students become more actively involved in their own learning through cooperative learning experiences and sharing in the classroom. In the final stage, invention, teachers have reflected on their ideas about the nature of instruction, and are ready and willing to create fundamentally different learning environments in their classrooms.

The notion of teachers progressing through stages is not a new one in education. In the 1960's, literature from the business community was appropriated by educational reformers to develop a general model of adopting innovations (Rogers, 1995). This model suggested that individuals faced with decisions as to whether or not to change accepted practices could be viewed as lying along a normal distribution ranging from "early adapters", to the "majority", down to "laggards", and finally "resisters." The assumption was that the decision to implement new practices is one-dimensional, and that knowledge about the benefits that would accrue from use would outweigh the barriers hindering adoption— assumptions that weakened under critical analysis when the greater complexities of schools and teaching practices became evident (Kerr, 1996). More sophisticated treatments of the process of innovation appeared in the 1980's. Investigators who noted the uncertainties, problems, and fears of teachers suggested a "concerns-based" adoption model and urged that innovations be thought of not as a dichotomous choice but rather as possibilities that would allow for a number of levels of use (Hall & Loucks, 1987; Kerr, 1996). Still other, more recent stage theories have attempted to explain how teachers progress specifically in their pedagogical use of the World Wide Web (Sherry, Billig, Tavalin, & Gibson, 2000).

Stages theories may be useful as a heuristic for teachers to critically examine the levels of technology integration in their own classrooms. However for researchers, the idea of stages as a linear, universal path that all (or most) teachers follow is problematic on several levels. In the ACOT studies, for example, it is not clear if stages were derived from the close observations of individual teachers, or, if the stages represented levels of different teachers and that an assumption was made that individuals progressed from less to more advanced stages over time. Also, because this particular stage theory posits novice users of technology as teacher-centered and describes how these individuals eventually use technology for collaborative, student-centered teaching only in the later stages, it apparently precludes from the model teachers who are initially student-centered in their instructional approaches or who already have a degree of technological expertise. Even if one accepts the proposition that stages, as universal entities exist, and that teachers move from one stage to the next, it remains unclear as how individuals make leaps of progress and whether this is done by observing others, experiencing critical incidents, employing individual insight, or interacting with other teachers in various settings.

In focusing more closely on individual teachers, other researchers have investigated the ACOT classrooms and found considerable variation in the instructional uses of technology. These researchers claim: "teachers content and pedagogical knowledge, we believe, provide key explanatory variables underlying our uneven findings" (Baker, Herman, & Gearhart, 1996, p. 196). The original ACOT researchers, on the other hand, postulate that teacher beliefs about learning, and about student and teacher roles in the classroom have a powerful impact on how teachers think about the use of technology.

They found that teachers vacillated between instructional approaches that had worked for years and new approaches that seemed more appropriate in their technology-rich classrooms— vacillations caused by dilemmas stemming more from long-held beliefs about teaching than from problems inherent to using technology. These researchers claim that when teachers shifted from long-held beliefs that learning activities needed to be divided into discrete subject areas, they began to incorporate more project-based instruction and became less concerned that the technology was taking time away from other subjects; when teachers moved away from the view of teacher as expert and their classrooms became more student directed, concerns about student experimentation and disruption of teacher plans diminished (Sandholtz, Ringstaff, & Dwyer, 1997).

Another impact on teacher learning identified through the ACOT studies was social interactions among teachers.

> [P]erhaps the most important type of support that teachers received was not from the ACOT staff, but from each other. In the process of change, ACOT teachers turned to their colleagues for emotional, technical, and instructional support. They collaborated together, shared ideas for a specific lessons and taught each other new skills. As a result, ACOT teachers who joined the project in later years moved more quickly through the evolutionary stages (Sandholtz,et al., 1997, p. 179).

Unfortunately, there is little information about how teachers intersected with each other within their particular institutional contexts to create new understandings about technology.

More recent large scale studies of exemplary computer-using teachers reinforce the notion that teacher learning and innovation thrive in environments where there are others who are experimenting with technology. In a national survey of 516 3rd through 12th grade teachers, Becker (1994) found that of 51 separate teacher-environment variables examined, the one that exhibited the largest difference between exemplary and other computer-using teachers was simply the total number of teachers at their school who used computers. The absolute number of computer-using teachers was even more closely related to the presence of exemplary computer-using teachers than the proportion of teachers in a school who were computer users. He goes on to say that teachers

> ...must have access to other people from whom they can learn, either experts who have already mastered the resource or a community of teacher-learners who pool their efforts and share their exploratory findings (p. 303).

In contrast to the notion of social/professional interaction as a catalyst for the transformation of teaching with technology, stands one of the most controversial suggestions about computers and teachers—that the computer itself is a change agent (Miller & Olson, 1994; Moursund, 1991). In a study of more than 153 schools where social support networks for teachers and sufficient technological infrastructures are in place, Becker and Ravitz (1999) found that teachers' sustained use of computers and pedagogical exploitation of the Internet is related to their increased use of constructivist teaching practices. They claim that these conditions may even change teachers' pedagogical beliefs that underlie such practices. In particular, frequent computer and Internet use appear to be related to teachers (a) being more willing to discuss a subject about which they lack expertise and allowing themselves to be taught by students, (b) organizing multiple, simultaneous activities during class time, (c) assigning long and complex projects for students to undertake, (d) giving students greater choice in their tasks and the materials and resources they can use to complete them, and, (e) increased recognition of the initiative that students can take outside of class to do high-quality work. Becker and Ravitz infer from their data that

> ...the relationship between technology use and pedagogical change is truly causal and not the mere conjunction of innovative teachers who happen to both use technology and develop a more constructivist pedagogy. However, this [work] still leaves unanswered the question of whether the causal impact is limited to teachers who were already inclined to teach in a constructivist manner and simply needed the appropriate resources to do so, or whether the experience of using computers or the Internet in a substantial way with students itself leads otherwise "non-constructivist" teachers to rethink their pedagogical priorities and philosophies of teaching (p. 381).

The notion of computer as change agent was present in the language describing the ACOT studies as well. Project leaders claimed that, over the years, the technology was "pushing" teachers toward constructivist teaching. ACOT project leaders claim that when they began the project they had no preconceived ideas or bias about what instruction and learning would look like in classrooms. The aim, they said, was solely to support teachers with technology. Despite these claims of observer and support staff neutrality toward of instruction, we cannot be sure that the support staff supplied by ACOT did not in some way help move the teachers toward constructivism (Baker, et al., 1996; Budin, 1999). Despite the allusions to the influences of the presence of technology, the authors state that:

> [o]ur research suggests that the introduction of technology to classrooms does not radically change teaching; instead technology can serve as a symbol for change, granting teachers a license for experimentation. (Sandholtz, et al., 1997, p. 171).

Other scholars have stated that technology "encourages" student-centered, cooperative learning, (Mehlinger, 1996) and that technology implementation "inspires" teachers to use more complex tasks and materials in instruction (Means, 1994). However, it is the growing consensus in the research community that the mere presence of technology can influence neither teaching nor learning (Cuban, 1986; Miller & Olson, 1994; Tobin & Dawson, 1992; Windschitl, 1998).

Although correlational, experimental, and otherwise etic research provide us with a wealth of information about teacher technology use and development of instructional practices, they tend to reinforce the conception of the computer itself as an agent of change rather than as a tool whose meaning and utility is

negotiated among individuals situated in specific social, institutional, and cultural contexts. Honey, McMillan, and Carrigg (1999) have suggested that to explore how teachers come to use technology in the service of reform-oriented goals requires looking at technology use in context and gaining an understanding of how teachers' technology use is mediated by factors such as the organization of the classroom, their pedagogical beliefs, and the socio-cultural setting of the school.

In light of these research objectives, two key ideas are absent from the current literature on teachers learning to use technology— ideas which have profound implications for understanding instruction in technology-rich environments. The first is how teachers, over extended periods of time, co-construct technology-related norms, beliefs and practices with peers and students. The second is how teachers' learning evolves within the specific social, institutional, and cultural contexts to shape technology-related instructional practices.

Sociocultural Perspectives on Teacher Learning

Traditional views of teacher learning see the individual teacher as the "non-problematic unit of analysis" (Lave & Wenger, 1991, p.47)— an assumption that underlies much of the research on teacher learning, including the teacher socialization literature (e.g., Lacey, 1977), studies on teachers' ways of knowing (e.g., Calderhead, 1988) and the expert-novice literature (e.g., Leinhardt, 1989). Most current studies in these areas are heavily influenced by cognitive psychological theory, an approach that views learning as changes in the ways knowledge is structured and represented in minds of individuals (Stein & Brown, 1997).

The goal of most analyses conducted within a cognitive psychological framework is to identify associations and trace changes in individual teachers' knowledge, beliefs, and instructional practice. This approach recognizes the importance of identifying contextual factors that influence the change process (e.g., characteristics of staff development experiences, school climate, or the opportunity to interact with colleagues); however, these contextual features of teacher learning are often portrayed as a stage upon which teacher thought and action are enacted. Contextual details, in this view, remains static and non-interactive with the analysis of learning (Resnick, 1991; Stein & Brown, 1997).

In contrast to psychological approaches that focus on the individual, sociocultural approaches focus on communities in which individuals participate. Sociocultural theorists view learning as "something that happens between people when they engage in common activities" (Bredo, 1997, p. 35) and that results from individuals bringing varying perspectives and levels of expertise to the work before them. According to Rogoff (1994), "learning is a process of transformation of participating itself....how people develop is a function of their transforming roles and understanding in the activities in which they participate." (p. 209). As individuals work toward shared goals, they together create new forms of meaning and understanding. These new meanings and understandings do not exist as abstract structures in the individual participants' minds; rather they derive from and create the context within which individuals are co-participants (Soltis, 1981).

Using sociocultural theories to understand teacher change, then, channels our attention away from the cognitive attributes and instructional practices of individual teachers and toward the collaborative interactions that occur as teachers attempt to develop and improve their practice. This interaction is characterized by problem-solving action carried out in specific social contexts whose structures have been developed through historical, culturally-grounded actions. Cultures are infused with notions of ideal societal futures that are promoted through the ways in which the cultural activity is structured. Participants in a given culture aspire to culturally defined futures that motivate their activity and the ways in which they mediate one another's progress toward those goals (Grossman, et al., 1999).

These social contexts are products of a cultural history in which individual histories converge. Social contexts are thus relational and value-laden. The social context of learning to teach with technology include shared imagined outcomes, relationships among participants, underlying philosophies of the institution, and

the kinds of activities that engage participants in learning. Even when emphasizing the interactions among participants, it is necessary to take into account the history that each participant brings to the setting (Smagorinsky & O'Donnell-Allen, 1998). As Minick (1985) points out, "actions are at one and the same time components of the life of the individual and the social system [and] will be defined and structured in certain respects by the broader social and cultural system" (p. 257).

Another element of the sociocultural perspective relevant to this study is the concept of settings (also known as activity settings). Settings, as opposed to social context, refer to the more immediate social structures within which learning occurs, marked by the specificities of time, place, participants, goals, and motivations. Settings can be formal situations, such as university classes in which goals are explicit and there is long-term joint activity, or, they can be transitory, highly informal encounters such as sharing conversation during a carpool (see Grossman, et al., 1999).

Arguing that learning occurs all the time, regardless of whether or not explicit teaching events have been arranged (Stein & Brown, 1997), sociocultural theories invite us to look beyond those formally structured events to other times and places (settings) in which individuals learn. Teachers learn from conversations in hallways, arguments in the teachers lounge, phone calls from parents, the successes and failures of their peers in the classroom, their students, and from the act of teaching itself. Perhaps the most overlooked of these is during the practice of teaching. In the literature we find references to teachers' learning through their daily classroom practices. Teachers learn not only by planning for lessons, by executing these lessons and receiving feedback on what interests students, how they respond to various instructional strategies, and what they are capable of learning (Cobb, Wood, & Yackel, 1990).

This conception of settings for learning being informal, transitory, and open to multiple participants, is broadened from the Vygotskyian notion of setting which focuses primarily on dyads of mentors and less experienced novices. For most activity settings in schools and especially in technology-rich environments, participants (students and teachers) are not divided sharply into mentors and apprentices. Rather, in any group, the various members will have different competencies, and individuals will offer the assistance of modeling and guidance to others in their own areas of greatest development (Talbert & McLaughlin, 1993).

In most schools, the notion of teachers having a personal relationship with mentors with dual expertise in technology and pedagogy is fanciful at best. It is rare that a single individual would have comprehensive intellectual authority to mentor other teachers. It is much more likely that expertise is distributed across other teachers and across students as well. Mentorship also ignores another fundamental reality in the culture of teaching: teachers learn to teach not only through experience but through solitary experience (Little, 1990). Colleagueship has been identified as an important institutional feature of teacher learning (Little, 1990) and in school reform (Fullan, 1991) however, detailed descriptions of how and about what teachers collaborate, as well as the mechanisms by which teachers' collaboration leads to change, have not been developed.

In addition to the notion of learners interacting with others to co-construct knowledge in a variety of socially and culturally infused settings, sociocultural theorists also assert that all human activity is mediated by tools (Wertsch, 1994). The computer, of course, is a powerful tool that extends the capabilities of the user to communicate with others, to access, organize, analyze, and re-present information, and to experience a range of simulated phenomena. The concept of "computer as tool" is relatively uncontroversial; however, the notion that computers are neutral devices that influence work only in the expedience they afford the user is naive (Bowers, 1988).

Computers shape the way work is approached, and they influence teachers' thinking as they develop curriculum and plan for instruction (Streibel, 1988). Consider the analogy of the invention of the hammer (Duffy & Cunningham, 1996). The hammer is the prototype of a typical technical tool. As the needs of a culture encouraged the invention of the hammer as a more efficient means of driving posts into the ground or joining two boards, the hammer altered the vary nature of carpentry itself. While it is true that the goal of driving a nail into a board is mediated by the use of the hammer, the invention of the hammer (and the

invention of so many tools of construction) has radically altered the character of the structures we build. Thus the invention of a tool and its use by people doesn't simply facilitate the forms of action that would occur anyway; the tool changes the form, structure, and character of the activity. This is true for hammers, and has proven true for modern technologies like the computer.

The word processor with which we write, for example, has not merely helped us become more efficient in writing, it has altered the vary nature of the act. Culture creates the tools, but tools can change cultures. Wertsch, (1994) has gone on to argue that the "essence of mediated action is involves a kind of tension between the mediational means as provided in the sociocultural setting and the unique contextualized use of these means in carrying out particular, concrete actions" (p. 204). Thus we return to the argument of whether, or how, the computer as a tool can mediate the fundamental nature of classroom learning by influencing the development of pedagogical perspectives, curriculum planning by teachers, or the more spontaneous, organic nature of classroom activity.

Methods

The choice of research strategy was based on the initial set of "how" questions this study proposed to address (Yin, 1994). At the onset of the study, a single, embedded case study was selected as the most relevant research design for investigating teachers' co-construction of norms and practices related to the laptop program. By incorporating multiple actors into the study's design—the subunits of analysis—analytical opportunities were expanded to enhance the interpretive and explanatory possibilities. Because "control over behavioral events" was not necessary and "contemporary events" were the focus of the inquiry, case study was chosen as the appropriate strategy for this investigation (Yin, 1994, p. 6).

Sampling and subjects

This study was conducted in a middle school during the 1998-99 and 1999-00 school years. The school was identified and evaluated as a potential study site after its decision to initiate a student laptop program. The evaluation considered three factors. Minimally, the teachers and the administration had to be willing to participate. The school's commitment to the program was also an important factor. A third factor was the size of the school and the number of teachers. Too few teachers might decrease the sampling pool on which this study's analytical power depended. Too many teachers and the number of social networks might weaken the comprehensive understanding sought by this study. In the final analysis, the site conditions satisfied the needs of the study.

After reviewing the first year interview and observation data, descriptions of teachers who might provide the most informative and instructive cases emerged. The following teacher characteristics were identified:

1. Recent involvement in an academic program.

Teachers whose recent academic experiences included participation in an advanced degree, teacher education or certificate program were believed to have had, at the very least, opportunities to read and review literature featuring current issues in teaching and learning. Teachers with current knowledge of theoretical foundations were believed to be more likely to apply that knowledge to instructional decisions than teachers with dated academic experiences. Because linkages between constructivism and educational technology are implied by some researchers, knowledge of constructivism and its conceptual foundations was a central concern.

2. Experienced teachers, but new to the school.

Teachers with prior professional experiences possess a grounding or basis on which comparisons can be made between schools. Eliciting teachers' comparisons was believed to be an effective form of surfacing and documenting teachers' beliefs. In addition, the recollections of teachers' recent socialization experiences were more relevant to the current educational climate in the school than recollections of teachers whose experiences occurred at the same school under a different set of conditions. While senior teachers'

recollections were important, the sources of influence were less transparent to new teachers, and thus more available to researchers.

Four of 11 teachers met the criteria as potential cases. Two of the four teachers had identical teaching responsibilities, one of whom was beginning her first year at the school. On the basis of her new teacher status and her need to learn about laptop use and school norms, she and the two remaining teachers were asked if they would be willing to participate in the study. All three agreed to participate.

Data collection

During the first year (1998-99), 11 teachers were interviewed twice and observed once. In addition, two administrators were interviewed, three student focus groups were held, and three faculty and board meetings were observed. The first set of interviews were designed to elicit teachers' beliefs about teaching and learning. The second set of interviews focused more on teachers' instructional planning.

In the second year of the study, over 100 hours of participant observation produced data collected in a variety of settings. Each one of the three teacher-cases was "shadowed" throughout the school day. The activities in which teachers participated and their actions were recorded in field notes. On numerous occasions, brief, spontaneous discussions between the researcher and teacher were reconstructed and recorded. All interviews were audiotaped and transcribed. Field notes were rewritten and typed on a word processor.

As stated above, participant observations represented the primary means of data collection for this study. The purpose of participant observation is to engage in activities appropriate to the situation and to observe the activities, people and physical aspects of the settings in which they participate. Walcott (1997) reminded us that participation in many cases varies and recommends that the researcher become as active as possible in the observation process. The anthropologist, Bernard (1995), provided five reasons for using participant observation while conducting an inquiry.

1. The strategy makes it possible to collect different kinds of data in a variety of settings.
2. Becoming a participant reduces reactivity, or the problem of people reacting to the researcher.
3. More sensible questions can be formulated and asked during interviews if the questions are from observational experiences.
4. As an intuitive understanding of what's going on in a culture is developed, the researcher is able to speak with confidence about the meaning of the collected data.
5. Some research questions cannot be answered by anything except participant observation (p. 140-42).
6.

It is important to note here that participant observation was selected as an appropriate investigative and data collection technique for this study after teachers and students had been interviewed and observed in the first year. The intentional use of multiple methods of data collection strengthened the construct validity of the study.

Analytic Methods

The data analytic procedure was highly iterative and consisted of reading the transcribed or archival documents, coding them, comparing and contrasting, and attempting to devise more inclusive topics and themes. Generally, analytic strategies are specific to the phenomena under study, but these techniques constitute the foundation of all qualitative studies (Marshall & Rossman, 1989; Miles & Huberman, 1994; Strauss & Corbin, 1990). Validity checks, including the use of triangulation methods, were utilized to ensure that the interpretation of the data followed from causal relationships (Yin, 1994). In addition, data collection and analysis proceeded simultaneously. As the data were collected, regular discussions between researchers became valuable opportunities to identify salient issues and topics.

Ethnomethodology was used in the final analysis. Ethnomethodology refers to "the investigation of the rational properties of indexical expressions and other practical actions as contingent ongoing accomplishments of organized artful practices of everyday life" (Garfinkel, 1967, p. 11). It is an attempt to understand the methods that people use to organize their world. Silverman (1993) sees these methods as being located "... in the skills ('artful practices') through which people come to develop an understanding of each other and of social situations" (p. 60).

One of the challenges of assuming the existence of "shared meaning" is whether it is possible to know the degree to which speakers truly understand each other's utterances. Duffy and Cunningham (1996) suggested that we examine how actors test the compatibility of their individual meanings as a way to uncover what knowledge, if any, was held in common. "[R]ather than assuming a shared meaning, within the constructivist framework there is a seeking of compatibility, a lack of contradiction between views" (Duffy & Cunningham, 1996, p. 171).

Membership categorization is an analysis technique used to identify tacit or hidden assumptions on which actors' understanding of each other and their social actions is based (Sacks, 1992). The descriptions people use to describe other people, events, or things around them constitute socially organized activities and their accounts "are features of the socially organized occasions of their use" (Garfinkle, 1967, p.4). The focus of ethnomethodology is on the skills actors use in producing and understanding descriptions. Teachers' accounts—their socially organized understandings—were analyzed using the membership categorization device to derive relationships specific to conversational settings. Discrepancies in teachers accounts signaled differences in understanding and provided adequate insight to surface assumptions.

Context of study

Fircrest Academy was a co-educational, Catholic independent school located in a Northwest city. The school was not associated with a parish; however, it had a long history of association with a Catholic order who owned the property. Fircrest consisted of a lower school (K-5) and a middle school (6-8) with 46 lay teachers—35 full-time and 11 part-time, 10 of whom held advanced degrees. A school policy capped class size at 14 students for Kindergarten and 18 for grades 1-8. The faculty was highly professional, experienced, well-educated and dedicated. Much of the subject material in the lower school was taught using a cross-curricular approach; but, in the middle school, more traditional approaches to teaching and learning were followed. Fircrest Academy was guided by the Cabrinian tradition of educating hearts and minds.

Approximately 150 students attended Fircrest Academy's middle school. The school attracted students who were highly motivated and whose academic ability was average or above average. Parents expected an academic program rigorous enough to prepare students for entrance into private high schools and universities. Whenever members of the school community described the tenor of the school, they commonly invoked the metaphor of "family". The actual student family was affluent and actively involved in the school on a variety of levels. High parental expectations for both students and teachers kept the faculty alert and responsive to all forms of parent communication. Parents pinned the success of their children on the shirts of teachers and were not shy about expressing their opinions on all aspects of classroom activities.

Resources and facilities for supporting at-risk or disabled students were not available. While safety issues were certainly on the minds of many in the school—for example, an earthquake retrofit of the gymnasium was recently completed—students' personal safety was seldom a topic of conversation among students or the faculty. And, with the exception of computer classes, vocational courses were not offered. Middle school students were required to purchase a laptop computer and be prepared to use it starting in sixth grade. Keyboarding skills, basic hardware and software familiarity were assumed and not explicitly taught to the middle school students.

During the last ten years, the school devoted much of its resources to the consequences of expansion. A recently concluded, sequential increase in the number of classes, from one to three, per grade consumed much of the school's energy as it grew and transformed itself. As the enrollment increased, so did the issues

associated with running the school. Governance procedures and the organizational structure were revamped. The composition of the Board of Trustees changed slowly to reflect the interests and involvement of increasing numbers of parents. In the summer of 1999, the board hired its fourth Head of School in ten years, crafted an improvement plan, and was in the process of its implementation. The school community was very familiar with concept of transition.

The seeds for Fircrest's laptop program were sown by a former administrator who, after returning from a national educator conference on laptops, became convinced that the laptop program was worth pursuing. Encouraged by the program's success at a nearby sister school, by a general belief in the inevitability of portable computing in schools, and by a desire to be on the "cutting edge" of educational technology, the board approved a plan to require middle school students to own laptop computers beginning in 1998. The board allocated resources for infrastructure installation, and created a new administrative position, the Director of Technology, to manage the laptop program and all aspects of the school's information services.

While the technical capacity of the school was upgraded, the expertise of its teachers was correspondingly enhanced. Professional development was an integral component of preparing the middle school teachers for the laptop program. One year prior to the program's implementation, the teachers received free personal laptop computers and attended laptop workshops. During this period, in-service workshops and technology-based discussions were common, and faculty meetings began to feature brief highlights of specific software functions and possibilities for curricular integration. Teachers' professional development opportunities continued, for a time, once classes with students and their laptops were underway.

Because some students did not have Internet access at home, the school originally planned to purchase a wireless modem for each student to use with their laptop. The administration wanted to support a vision of ubiquitous computing for all its students and wireless modems represented a means to achieve that vision. Under this plan, student access to the Internet would not be limited just to classroom use or to plugging-in to a telephone jack at home. Instead, students would have the capability of using the Internet in their family car, on local field trips, or at a friend's house. But, before the laptop students attended their first classes, the plan was scaled back due to budgetary concerns and acceptable use policy issues. As an alternative, each teacher received eight wireless modems for classroom use. This arrangement was adequate, but it was not the one that teachers had expected.

Half-way into the first year of the laptop program, administrative disputes inadvertently cast the laptop program into the hands of the teachers. The resignation of the Director of Technology was immediately followed by the resignation of the Head of School. A direct result of the shake-up was the discontinuation of the weekly best-practices-with-technology vignettes at the faculty meetings. In addition, students complained about the strain of carrying the additional weight of their laptops up and down two and three flights of stairs. Slowly, the bloom began to fall off the laptop rose and, without administrative leadership, middle school teachers were left to invent their own version of Fircrest's laptop program.

Findings

The following case summaries describe the developmental changes associated with teachers' learning to use laptops in their classrooms. All three participants, Julia, Carol, and Livan, (all potentially identifying names used in this study are pseudonyms) were relatively new teachers at Fircrest. Data from Julia's case were collected during her first and only year at the school. Carol and Livan's data were collected in the middle of their third year at Fircrest.

The Case of Julia Walters

Julia decided to earn her teacher certification after leaving a previous career and raising her family. She completed a teacher education program and was hired to teach fifth and sixth grades at a parochial school where she taught for two years. Subsequently, Julia applied to and was hired at Fircrest as a sixth

grade homeroom teacher. The position was attractive to her because it did not involve teaching science, a subject for which she felt under-prepared to teach in her previous position. When Julia learned that all of her sixth grade students owned laptop computers, she looked forward to the challenge of learning more about teaching with technology. Although she was familiar with computers, Julia had never used technology, let alone personal laptops, with students in a classroom setting.

Julia's first introduction to the entire Fircrest middle school faculty happened during the summer while she attended a two-day technology workshop just prior to the start of school. A few of teachers introduced themselves and welcomed her to the faculty, but not all of them. "After awhile and for well over an hour did I meet anyone. And there were people in that room that never even came up and said hello to me. Even after a whole day." She left the workshop perplexed and found it curious that out of a dozen teachers, she had only met a few.

Once the school year began, she eventually did meet the other teachers, but, as the year progressed, her collegial relationships became strained. At faculty meetings, Julia was critical of the school's discipline policy and did not understand why her colleagues were so indifferent to the unacceptable behavior she perceived on the part of the students. Consequently, she looked forward to her second year when the anticipated improvements in curriculum and changes in the discipline policy would be implemented by the new Head of School.

All three sixth grade teachers agreed to cover the same content in their classes, but in comparison to her colleagues, Julia's morning schedule contained more flexibility for doing so. Julia created an integrated curriculum and incorporated religion, social studies, language arts, and literature into one uninterrupted three-hour block. Because her classroom did not have a TV monitor, her students were exempt from watching an early morning, 10-minute commercial news telecast transmitted to other classrooms. Also, students in the other two sixth-grade classes had to contend with leaving their homerooms to attend math or science classes. Although the schedule reinforced Julia's curriculum goals, it wasn't conducive to collaborations with other sixth grade teachers.

Teaching with technology was a completely new approach for her, but she believed that it was the normal and expected way to teach at Fircrest. Despite her admitted unfamiliarity with classroom computers, Julia started the school year by creating a Web-based map skills project in social studies. Her students "traveled" around the world in fictional hot air balloons and used global coordinates to navigate from one destination to another. She arrived at the idea after she "just thought up" the project, "...off the top of my head. I'm just that way." In addition to developing map skills, she wanted the project to have an interdisciplinary flavor, to incorporate mathematics and to address multiple intelligences. Her students were required to conduct their research on the Web. They had to determine the speed of hot air balloons and locate the seven wonders of the world. In the beginning, her project took a lot of time to conceive, but at the end, she said her students were "really motivated."

Initially, Julia worried that she did not have the skills to teach students equipped with laptops. She created the map skills Web-based project as a way for her to learn how to use the laptop in class, and once it was completed, she did not attempt another. During one interview, she conceded, "You know, this is my first year here and I just wanted to feel my way through this first year." Julia's students used their laptops when word processing complemented the writing process, usually in their religion and language arts classes. Other times, she asked her students to refrain from using their laptops and to concentrate instead on improving their cursive handwriting. On rare occasions her students used the World Wide Web to conduct research, but she decided that the wireless modems were too slow and the wait times were too long to continue using the Web.

Again and again, Julia's patience with the technology was tested. When she tried to lecture, her students stared at their laptop screens, prompting Julia to tell students to lower their screens and to pay attention to her. When students walked around the desks, too many power cords and too few outlets created a classroom hazard. If the laptop's batteries were discharged, a warning beep was emitted, and the class was

disrupted. Exasperated with the management issues, Julia told her students that if their laptop batteries were not charged before class, then they would have to do without their laptops. "I heard you don't use them in other classes" was her response to the protestations of students. "The only time you need to have your laptop out is in the morning when we do our [religion assignment]." The students continued to follow a pattern of uniform laptop use where every student was expected to use the laptop at the same time to complete an identical assignment.

The tension she experienced contributed to her uncertainty about when to use the laptop and what to use it for. As her planning time was consumed with preparing for five different classes, Julia acquiesced to the demands of her workload and became less concerned with learning how to use the laptop. She lowered her own expectations for learning how to use the laptops after she asserted that laptops were not the faculty priority she originally thought they were.

Julia's opinions of her first year teaching experiences at Fircrest were mixed. Her conceptions of teaching and learning were largely shaped by previous parochial school influences, many of which were missing from Fircrest. She believed that the Fircrest students possessed too much freedom and their disciplinary environment was too lax. Since appropriate group behavior was a priority for Julia, she established a system of rewards and sanctions as a way to encourage her students to follow class rules. However, inconsistent enforcement of the rules resulted in few of the desired behavior changes, while new classroom management challenges emerged just about every day. After four months she conceded, "I'm not quite in synch with this environment yet."

One of the first tasks the new Head of School asked the faculty to complete was an entire curriculum map of the school. Julia volunteered to be on the curriculum mapping committee, the only middle school teacher to do so. She was under the impression that the other middle school teachers didn't seem to care about curriculum mapping. In fact, she said, they didn't seem too concerned about standards. Julia believed she was hired, in part, because she was familiar with the State academic standards. "[M]aybe it's related to style, you know. I mean, she hired me. The administration who worked here before, they hired everybody else that's here and they built the community of what [Fircrest] is. But, I was hired by her and maybe I projected more of her style." The prospect of the administration moving toward a standardized curriculum at Fircrest was an important consideration in Julia's decision to remain for a second year.

The Case of Carol Peters

Carol Peters taught as a substitute teacher for two years at Fircrest before she was hired full-time. Her previous 10 years of experience consisted of teaching social studies in both public and private secondary schools. Carol was impressed with the image of community that was projected by the Fircrest students, parents, and staff. Her colleagues were helpful and ready to assist her in the event that she ever needed them. She saw the staff as unified in purpose, focused on academic achievement, and committed to the students. Carol understood that her colleagues' dedication to the students' well-being was due to a genuine, professional concern shared by the entire faculty.

Carol's teaching responsibilities included seventh grade language arts and social studies classes. Prior to teaching at Fircrest, Carol taught nothing but social studies. Few opportunities existed for Carol to modify the standardized language arts curriculum, but as was the case with her peers, she was entrusted with the creative freedom to develop the social studies curriculum. She and a colleague who had identical training in a specific curricular approach to social studies instruction, developed a number of project-based activities for the seventh grade students. Her colleague considered Carol to be a technology expert, and consequently Carol constructed the connections between their curricula and the laptop. They were particularly excited about the chance to work on a CD-ROM history of Fircrest Academy. An extensive archive of Fircrest's past was available, and they viewed this as an opportunity to use the context of the school to teach their students about State and local history.

A second colleague with whom Carol worked closely shared Carol's desire to make the laptop work

in her classroom. Both were recognized by their peers as the two middle school teachers who had done the most with curricular integration of the laptop. Her colleague, whose pedagogic techniques served as models for Carol, became an important source of ideas and feedback. Both teachers enrolled in an educational technology certificate program at a local university and participated in online courses. They worked together on assignments and devised new laptop activities and strategies to challenge their traditional notions of teaching and learning. Their relationship recently culminated in a joint presentation made to other laptop teachers at a regional conference of laptop schools. Because of their collaborations, Carol's knowledge of curricular uses of laptops continued to grow and develop as she experimented and tried new ways to use the technology.

Carol discovered that her laptop lessons and activities had an impact on students as independent learners. She noticed that the laptop "... focuses their attention on what they're doing, not what I'm doing all the time." Just as she recognized that her students were learning how to sort and prioritize electronic information, she believed it was her responsibility to help students learn how to use the software as well as learn the subject matter. Searches for online student resources or learning how to operate the software consumed much of her lesson planning time. Overall, she was convinced that the laptop made an important contribution to student learning and she was committed to using it in the most effective ways that she could.

The impacts of the laptop on student learning led Carol to discover a number of related instructional issues. One issue in particular, the time required to teach and learn software-related skills, impacted upon classroom schedules and curriculum timelines. After Carol attended the faculty multi-media summer workshop, she immediately applied the new skills and ideas she learned to the creation of a "kiosk" project. The project instructions directed students to use presentation software to communicate an important message and, in the process, utilize the available multi-media tools. During the project, she explicitly taught her newly acquired audio and video techniques to her students. Although the students were challenged by all the multi-media pieces they had to learn, she reached a point when it was necessary for her to decide how much time to spend on the project. "Curriculum suffers," she said. "You have to make a decision."

Carol continued to learn from what worked best for her students and what constituted the most effective classroom arrangement of her students' desks. During the study, she rearranged the desks in her room twice—from students seated in groups to students seated in rows, and back again. She wanted the students to work more often in groups, but because she was adjusting to the new social dynamic associated with using laptops, sometimes the groups deteriorated into chat sessions. When the noise from these sessions continued to escalate, Carol asserted her authority and rearranged the desks into rows. Despite the group arrangement of desks, students worked on individual assignments. Few of the laptop projects were the single result of cooperative group efforts.

Carol looked forward to the time when she would be able to perceive of herself as a true facilitator of laptop learning. Effective use of the laptop meant that she had to conduct her classroom differently. She wanted to move away from what she believed was a reliance on didactic instructional approaches and toward more student-centered, project-based lessons. Although her students' parents did not disapprove of Carol's activities, they communicated to her their uncertainty about the effectiveness of the project approach. Eventually she came to the conclusion that it was not necessary nor desirable to use the laptop every day and her instructional approaches continued to evolve.

The Case of Livan Gonzalez

After relocating to the Northwest in the middle of the school year, Livan Gonzalez expected to work as a substitute teacher before finding full-time employment. Within a month, Livan was hired as a full-time math co-teacher at Fircrest. The following year Livan taught eighth grade algebra and one seventh grade math class. He embraced Fircrest's professional climate and collegial atmosphere. Both contributed to his belief that he was a full partner with the middle school teaching team. The connection he felt to the other seventh grade homeroom teachers was due, in part, to collaborations on curriculum and governance issues.

Because he taught math to the entire eighth grade, he felt connected to the other three eighth grade teachers with whom he closely worked. After only two years at Fircrest, Livan had earned the full respect of the middle school teachers as a trusted colleague and professional educator.

When Livan's students entered his classroom, they sat down with their three partners, located their assignments on the whiteboard in the front of the room, and went immediately to work. When the period started, Livan communicated to the students his expectations for the period. If a crucial concept was novel or required a brief review, he asked his students to analyze the concept in context and to collaboratively construct a tenable solution plan for the problem. Instead of directly telling students "how-to", Livan developed an investigative approach to student learning, which for him, was a recent change in his pedagogy. If time remained at the end of the period, Livan conducted a discussion about the assigned problems and the mathematical thinking the students used to solve them. It was always clear to students what Mr. Gonzalez's expectations were for each period.

Beside the lesson's objectives and academically appropriate activities, Livan's lesson plans included managing classroom contingencies. His tolerance for disruption was low. He believed that students were more motivated when they were successful, and so he tried to structure his activities and assessments to maintain a high level of achievement. His experiences also led him to believe that if students were held accountable for the work they did, they were more likely to complete their assignments. Livan was confident in his students' abilities to achieve at a high level.

After his first year at Fircrest, Livan's pedagogical understandings and strategies lacked the satisfaction he experienced in his previous years of teaching. He started to question some of his basic assumptions about how he taught and wanted to learn more about newer conceptions of teaching and learning. He wanted to know, for example, how teachers became facilitators of learning. He questioned the process of teaching algebra without knowing for sure whether or students actually learned math concepts or just memorized the algorithms for solving problems. Livan's questions about his practice and his content area led him to seek the answers in a graduate degree program at a local university. He was excited about the prospects for developing a deeper understanding of the learning process.

Being somewhat dissatisfied with the pre-existing algebra curriculum at Fircrest, Livan decided to cash-in on the curricular autonomy accorded to Fircrest teachers. He attended a National Council of Teachers of Mathematics (NCTM) conference where he learned about an algebra curriculum designed around an exacting set of standards. He preferred that such a curriculum have as its goal the continuous integration of math concepts and relationships as opposed to the traditional fare of sequential accretion of unrelated concepts. He also preferred that his students have as their goal not the completion of a textbook, but a deeper knowledge of the connection of mathematical concepts. After attending teacher workshops and training sessions to learn more about the curriculum, Livan adopted it the following year. As the school year progressed, he believed that the curriculum had engendered deeper learning and understanding in his students compared to the curriculum he used in previous years.

Over the course of the two-year study, Livan's perspectives about the classroom role of laptop computers changed significantly. The eighth grade students were not required to purchase laptops in the first year of the laptop program and so laptops were not used in Livan's algebra class. During the year-long "break-in" period and in preparation for the following year of laptop-equipped students, Livan developed Web-based course materials for his algebra students and learned more about integrating the laptop into his curriculum. But, as the school year progressed, the few teachers who experienced success with laptops, in Livan's opinion, hurdled substantial obstacles that prevented the other teachers from learning more. Livan commented that teachers needed to adopt a "new mind set" because the laptop required changes to classroom management and it required teachers to teach differently. He found that assessment of technology projects was more subjective, which led him to question the laptop's effectiveness with helping students learn algebra concepts. From his observations he concluded, "I'm not going to abandon what I think the school wants me to do with math just to incorporate the technology."

Livan used graphing calculators and believed they represented a more appropriate technology for his students. He believed the devices complemented his instructional goals more than the laptop. The spreadsheet software on the laptops was useful for learning some concepts, he said, but the graphing calculators were more appropriate in the long term for most of the work he assigned. After the pilot year of the laptop program, Livan's skepticism about the laptop's effectiveness in the courses he taught increased. Livan believed that the laptop had more to offer students in classes other than mathematics.

Looking across the cases

Both Livan and Carol relished the professional autonomy they possessed. Years of administrative transitions built and reinforced a professional community of teachers who were strong instructional leaders. Despite institutional growing pains, teachers stayed their course and continued with the work of educating students' "hearts and minds." The experienced teachers had established their own set of rules and procedures for accomplishing organizational goals and communicated them to new teachers when they arrived. Carol commented that "[t]here's an institutional memory that seems to be alive and well and is passed along by all the building teachers, the more senior teachers." Her comments were echoed by Livan, "[t]here's sort of the ambiance of a place, you know, how it runs, the dynamics between parents, students, and teachers. He filled me in on that, as well." The collaborative climate, the expectations they had for one another, and the degree to which they went out of their way to maintain connections with their students and with one another were unique faculty qualities.

One of the primary responsibilities of the middle school faculty was to keep one another apprised of individual student's academic development. Internal e-mail or faculty lunch discussions were venues for reviewing student progress. Everyday, Livan and Carol ate lunch with the rest of the faculty and had an opportunity to compare notes and discuss specific cases. Faculty lunches were not only valuable for cross-referencing student progress, they were the primary means for the socialization of new teachers and for affirming community norms. Teachers also conversed during class breaks at opposite ends of the hallway where they tended to cluster according to their classroom proximity to one another. Teachers' commitment to provide parents with up-to-date and consistent information about their child's academic progress ensured that parents received reliable feedback and maintained the social cohesion of teachers.

Julia, however, chose not to participate in the lunchroom conversations and seldom interacted with colleagues in neighboring classrooms. The faculty communicated a strong commitment to the welfare of their students and she did not share the same orientation. Julia believed she was accountable to the parents and the administration first, and students second. The role of Catholic education in the school was another point of departure between Julia and other faculty members. Julia reported that "communication chasms" between she and the other members of the middle school faculty prevented her from creating stronger collegial relationships.

Julia's preoccupation with a strict standards-based approach to learning also stood in direct opposition to the professional orientation and concerns of other faculty members. Julia's teacher education and previous parochial school experiences never prepared her for the level of autonomy she possessed at Fircrest. She seemed to confuse "standards-based" curriculum with the notion of a "standardized" curriculum. The combination of this misinterpretation and her general lack of teaching experience or lack of previous experiences at Fircrest contributed to her retreat from collegial interactions. Initially, the isolating effects Julia experienced were due, in part, to a schedule that prevented her from working with other sixth grade teachers. But, as the school year went on, the isolation was further reinforced by professional conflicts and tensions that interfered with her ability to take part in faculty-defined activities.

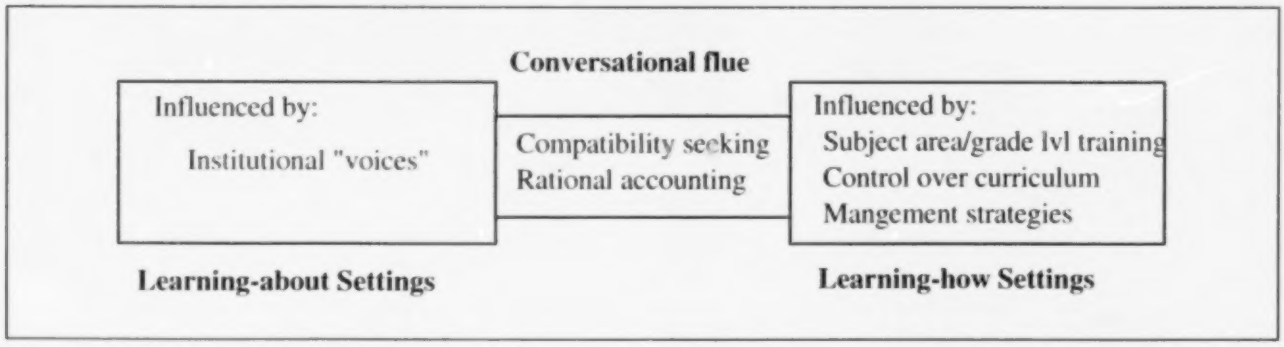
The differences in expectations for colleagues and the realities of an established collegial culture created a set of contrasts that were used to isolate specific types of teacher conversations on the subject of laptops. We identified settings in which conversations and activities centered on one of two topics: "learning about" the role of the laptop in the classroom and "learning how" to use laptops in the classroom

(Figure 1).

Learning-about Settings

As sites for transmitting and negotiating institutional norms and expectations, learning-about (LA) settings served a key organizational function. Teacher access to LA settings, its activities and its participants, was a crucial component of developing a deeper understanding of the organizational roles each teacher was expected to fill. Participants in LA settings consisted of groups of teachers or a combination of teachers, students, administrators, and parents. There they learned about each other, the students and their families, the school, its history, and its culture in both formal and informal settings distributed across the entire school, from the classroom to the lunchroom.

Figure 1. Initial analytic model: Sources of influence on settings in which teachers co-construct technology-related norms and practices.



The primary source of influence on LA settings consisted of Fircrest's institutional priorities and performance expectations. These institutional "voices" dominated the conversational contexts and delimited conversational parameters. For example, inviting (or not inviting) participants, scheduling meetings, setting agendas and other organizational actions limited discussions to a specific set of topics with a predictable set of conversational rules. Usually, laptops received only indirect references in these discussions. Activity goals did not relate directly to the laptop and teachers learned about laptops in the context of the conversation.

For example, each day the middle school teachers lunched together and shared in discussions framed by socially agreed upon boundaries. One of the common subjects was student academic achievement. Lunch was a rare time during the day when teachers gathered in one place at one time and had an opportunity to confer with other teachers on the progress of one or more students. On one of these occasions, a teacher noted that a student needed some guidance to improve his organizing skills. During this discussion, the teacher referred to the student's laptop:

T1: . . . even the files on his laptop are not organized.
T2: That reminds me. I need to defrag my hard drive.
T3: I need to learn how to do that.
T1: I asked him to create folders for his files, but it still needs to be reinforced.

A publicly defined (and negotiable) purpose for laptops—organizing skills—was embedded in the context of the activity—ensuring peer awareness of student needs. Access to the social language in this example required a participant to infer from the social language that organizing skills were an important part of the educational program of the school. A teacher who accessed the language of this exchange became familiar with the student and his academic needs, the laptop's purpose as an organizing device, performing regular laptop maintenance, and a peer who could share technical knowledge about the laptop. Teachers who possessed contrary beliefs about the importance of organizing skills were unlikely to access the social language and, as a consequence, they were unlikely to retain the information about laptops.

Learning-how Settings

The central activity in learning-how (LH) settings focused on the development of teachers' knowledge and facility with integrating the laptop into their curricula. Compared to LA settings where the broader context of school life and culture bracketed laptop information, classroom realities saturated the context of LH settings. In LH settings, teachers learned the delicate art of blending laptops into a complex

formula of classroom ingredients.

LH settings were more widely distributed than LA settings and were not confined to the school building. Teams of teachers who attended professional development workshops, seminars, or conferences occupied LH settings. Teacher teams who met during their planning periods to develop lessons and activities in which the laptop had a fundamental role also occupied LH settings. Throughout the lesson planning phases, curriculum and laptops shared the stage in the theater of teachers' minds with the theater played out in the form of collaboratively developed activities.

Teachers' subject area or grade level training tended to have a greater influence on LH settings than did other factors. Teachers were predisposed to use laptops in ways that corresponded to instructional models in their disciplines. Additionally, a desire to maintain control over the curriculum process (e.g. collaborations with colleagues to define learning objectives and create corresponding activities) and learning how to manage the impact of the laptop on classroom interactions also emerged as motivating factors and sources of influence.

Teachers' understandings of classroom laptop norms flowed back and forth between LA and LH settings through a conversational flue. LH activities supplied teacher-participants with a range of curricular understandings from which only a few were selected and transferred into LA settings. Modified by the institutional influences in LA settings, teachers' understandings were revised and subsequently applied to LH settings. The reflexive movement of teachers' understandings between settings was punctuated with briefings or accounts of their newly acquired knowledge. Teachers' accounting practices served two purposes: teachers publicly declared what they understood as norms for practice, and in the process, invited other teachers to negotiate new norms. Through this process, mutually determined roles for each teacher evolved from the multiple influences that impinged on individual beliefs.

Contradictions between teacher beliefs and the influences on settings prompted many teachers to reassess their understandings of the laptop's role in the school. Throughout the process of searching for compatible understandings, teachers managed to navigate the minefield of professional differences among their peers. Their search had the net effect of neutralizing some differences, but surfacing others. These differences were important areas for investigation.

Discussion

Our study sought to answer how teachers co-constructed norms and practices related to classroom use of laptop computers at Fircrest. The diffusion of a school-wide innovation required teachers to engage in a discursive process, a normative kneading, where multiple conversations conducted in multiple settings over time converged upon a set of standards for acceptable patterns of laptop use (Rogers, 1995). Conversations flowed through the school's network of settings, the circuitous routes of discourse and negotiations, that came to define the normative playing field for teachers' curricular decisions.

Teacher participation in these settings depended upon access to the activity as well as access to the social language used in the setting (Bahktin, 1981; [cited in Wertsch, 1991]). Access of the first type depended upon the spatial-temporal arrangement of actors and the organizational influences on interaction. Activities were successfully accessed when a teacher-participant was in "the right place at the right time." Achieving a second type of access, however, required that actors paid attention—at some cognitive level—to the social language that framed the conversation. Consistent teacher descriptions of peer choices to use (or not to use) laptops indicated that access to the social language led to their understanding of the various roles laptops played in the school.

The access to social language as a variable in teachers' learning to use technology places the notion of a "stage" progression in question. The case of Julia, who had very little background or training in curricular integration of technology, demonstrated how influences in settings can have a countervailing effect on teachers' development and classroom use of laptops. Julia's demonstrated expertise exceeded the entry level stage predicted by her experience. The fact that she started the school year with such an exemplary student

laptop project indicated that the greatest influence on her use of classroom laptops was her expectation that all Fircrest teachers needed to know how to use laptops. It was only after she experienced other aspects of the Fircrest culture that she was less likely to apply the same degree of ingenuity and creativity expressed by her initial laptop project to subsequent projects. Her inability to access the social language in specific LA settings negatively affected the continuation of project-based laptop activities in her classroom.

Because of her substituting experiences, Carol was involved in school conversations during the planning phase of the laptop program and was familiar with the school's technology infrastructure and expectations for laptop use before she was hired as a full-time teacher. Her knowledge of the situation motivated her to learn more about using laptops before the first students round of laptop students arrived. As she listened to the rhetoric surrounding the use of the laptops, she attempted to fit her classroom reality with the trumped up notions of changed professional lives. She did admit that the laptop was moving her toward more constructivist approaches to teaching, but that she was still having trouble distinguishing between when to use and when not to laptops. The LA settings did not provide her with the support for innovation she needed. She was forced to look beyond the school for instructional models and additional knowledge.

A number of factors coincided with Livan's decision to investigate a pedagogical approach that was more in line with constructivist thinking. He questioned some of the basic assumptions on which was the algebra curriculum was based and he was determined to locate a more appropriate program for his students. Livan was a student of his profession and understood the relationship between the State standards and NCTM standards. His desire to pursue another graduate degree was not precipitated by the laptop, but was associated with the wider conversations taking place in math education. Whether the laptop was the catalyst in his thinking about changes in his practice was not clear.

One area of this study that was not investigated to any degree was the self-constrained use of the software tools. Fircrest teachers limited the design of their lessons and activities to the functions available on the "office" set of software tools that came pre-installed on their laptops. Whether this limitation was a function of learning to use laptops, or whether it was a function of an information vacuum within which Fircrest teachers learned to use laptops, the implications for understanding the effects of influences might be related to the effectiveness of software tools to meets participants' needs. In addition to the self-imposed limitations, the degree to which the laptops reproduced traditional methods of instruction was not investigated. If the purposes for using laptops were unclear and relatively undefined in the technology plan, teachers may have perceived the laptop to be a threat to their professional roles. Howell (1995) noted that replacement is not what teachers should be thinking about. He said, "Computers cause deskilling as well as reskilling. The challenge is to identify which parts of today's knowledge base are becoming redundant" (p. 99).

Conclusion

A sociocultural perspective guided this investigation into the influences of settings on teachers' co-construction of technology norms and practices. Two types of settings were identified in which different activities contributed to teachers' knowledge and understandings of student laptop use. Access to the setting was a primary variable related to the characteristic social language used in the setting. Learning-about settings were sites where institutional values were transmitted. Learning-how settings were influenced by teachers' own professional knowledge and featured activities in which skills, techniques, and information related to classroom use of laptops were transmitted. Teachers' periodic announcements of their pedagogical understanding related to laptop use opened the door to further negotiations on appropriate laptop use for individual teachers. The continual process of identifying institutional expectations for laptop use, finding out how to blend laptops into an existing curriculum, and contributing to a conversation about classroom laptop use came to define how teachers co-constructed norms for practice. It was a process that accommodated both

the "grammar of schooling" for Fircrest as well as a process for envisioning the ideal futures of Fircrest's teachers, parents, and students (Tyack & Cuban, 1995).

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[1] The most widespread and heavily funded of these is Anywhere, Anytime Learning which is supported by Microsoft and Toshiba. This organization maintains a Web site complete with success stories, discussion lists for teachers, grant opportunities, and it sponsors a variety of in-services and conferences for educators.

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